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(19)

(54) OPTICAL FIBRE CABLE

(71) We, STANDARD TELEPHONES AND CABLES LIMITED, a British Company, of 190 Strand, London, W.C.2., England, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to optical fibre cables.

According to the present invention there is provided an optical fibre cable wherein a plurality of sheathed optical fibres are separately stranded around and directly onto a tensile reinforcement member extending along the neutral axis of the cable, or directly on to a solid sheath covering said reinforcement member, such that the sheathed optical fibres are in direct contact with the reinforcement member or its sheath.

Both single mode and multimode fibres may be assembled into cables. A typical single mode fibre may have a core diameter of about 2 μm and a cladding diameter of about 70 μm, while a typical multi mode may have a core diameter of about 60 μm and a cladding diameter of about 70 μm. Except for the case of liquid cored fibres, core and cladding are generally made from materials having similar mechanical properties, and hence the mechanical properties of a single mode fibre will normally be similar to those of a multi mode one made of the same core and cladding materials. Therefore from the point of view of the mechanical considerations of cable making there is little difference between the processing of both types when similar materials are used in their construction.

Glasses used for optical fibre manufacture include fused silica glasses, borosilicate glasses, and soda lime silicate glasses. Overall diameters of such fibres have evolved in part from optical requirements but a limitation has been set by the brittle nature of the glass and the need to retain sufficient flexibility for incorporation in cables. Such fibres typically break at about 1—2% elongation when subjected to tensile stress, but behave elastically over most of the range of extension. This means that considerable stress can be applied without permanent deformation since the elastic moduli of glasses are high. However, as a result of their small cross-sectional area, the breaking tension of fibres is usually only of the order of a few hundred grams.

Some tensile reinforcement of individual optical fibres is therefore desirable merely to facilitate the laying up of a cable. This reinforcement may be provided by giving each fibre a plastics sheath. Such a sheath offers the possibility of further advantages, such as protecting the glass from chemical attack, and from damage by abrasion during winding and laying up operations. The sheath may also act to cushion the fibre from applied radial forces and give a measure of protection against the formation of kinks in the fibre of small radius of curvature. To take full advantage of some of these effects it would be desirable to use as thick a sheath as possible, but a compromise has to be reached in order to preserve adequate flexibility and to limit the total cross-sectional area of the cable for a given number of fibres.

When a system of parallel elements of uniform cross-section and equal length is extended, but not beyond the elastic limit of any element, the tension T developed is related to the strain S by the relationship:—

$$T=S\Sigma EA$$

where E is Young's modulus of elasticity of an element and A is its cross-sectional area. In the case of a plastics sheathed glass fibre the equation becomes:—

$$T=S(E_1A_1+E_2A_2)$$

where the subscripts 1 and 2 refer to the glass and the plastics respectively. In this context it may be noted that it is immaterial whether the plastics is bonded to the glass

provided that both materials are subjected to the same strain.

As a general rule the elastic moduli of plastics materials are considerably lower than those of glasses, so that in order to make a significant contribution to the tensile strength the area A_2 must substantially exceed A_1. On the other hand, since the flexibility of a cylindrical rod is inversely proportional to EA^2, it is advantageous to keep A_2 as small as possible by using a plastics material with a large Young's modulus. Typically extruded plastics such as high density polyethylene (HDPE), polypropylene (PP), nylon, and polyethylene terephthalate (PETP) have moduli in the region of 150 to 200 kg/mm², but some nylons extruded under ideal dry conditions can have a modulus as large as 300 kg/mm, though this is liable to degenerate to around 150 kg/mm in a moist atmosphere.

Assuming a modulus of 7,000 kg/mm for a glass it may be shown that for a 70 μm diameter fibre the limit of 1% elongation is achieved at a tension of about 150 grams for a base fibre. If however this fibre is sheathed in plastics material having a modulus of 300 kg/mm² 1% elongation occurs at a tension of 1 kg for a 0.6 mm external diameter sheath and at a tension of 2.5 kg for a 1.0 mm external diameter sheath. For a lower value modulus of 150 kg/mm² 1% elongation occurs at a tension of nearly 1.5 kg for a 1.0 mm external diameter sheath.

A tensile strength of the order of 1 kg is generally acceptable for the operations of cable making, such as bunching, stranding, braiding, sheathing, and armouring, but if the construction relies virtually exclusively on the sheathed fibres for its tensile strength, this strength is liable to be inadequate. In particular it is liable to be inadequate for withstanding the large force generally required to install cables in long ducts. This problem is overcome by disposing the individually sheathed fibres of the cable around a central tensile reinforcement member. The central location of the reinforcement member on the neutral axis of the cable ensures that the reduction in cable flexiblity resulting from the stiffness of the reinforcement member is at a minimum. The maximum stress developed in the sheathed fibres during banding of the cable is also minimised by locating the reinforcement member at the neutral axis.

Suitable materials from which to make the reinforcement member include plastics materials, glass, and steel. If a plastics material is used it is advantageous to employ a high tensile material whose elastic modulus has been increased by orienting the molecules by stretching at a temperature significantly below the melting point of the material. Oriented versions of plastics material such as HDPE, PP, nylon and PETP have Young's moduli lying typically in the range 1,500 to 4,000 kg/mm². This is still small compared with a modulus of about 20,000 kg/mm² for steel. However steel has the disadvantage that the yield strain is little more than 0.1% as compared with a value usually in excess of 1.0% for plastics clad glass fibre. This makes it difficult to realise the full theoretical potential of steel. This problem can be ameliorated by the use of a helically stranded steel reinforcement because with helical stranding the elongation of the reinforcement member is greater than the strain in an individual strand. Normally it is desirable to sheath a stranded reinforcement member, for instance in a plastics material.

This effect of helical stranding can also be used to advantage if the yield strain of the reinforcement member is greater than that of the sheathed fibres. Under these circumstances the sheathed fibres are arranged in a helical configuration around the reinforcement member. This requires that the sheathing should have a low enough coefficient of friction to allow relative longitudinal motion between adjacent sheathed fibres. The pitch of the helix must be relatively long so that it introduces neither excessive curvature, nor excessive increase in optical path length.

There follows a description of an optical fibre cable embodying the invention in a preferred form. The description refers to the accompanying drawing depicting a cross-section through the cable.

Referring to the drawing a group of eight glass optical fibres 10, having an external diameter of 70 μm, have sheaths 11 of polyethylene terephthalate (PETP) extruded around them. The external diameter of the sheaths 11 is 1 mm. The eight sheathed fibres are wrapped around a plastics tensile reinforcement member 12 in a long helix, typically having a pitch of about 20 cm. The reinforcement member which has a diameter of about 1.6 mm is made of an oriented PETP. The assembly of the sheathed fibres and the reinforcement member is wrapped with PETP tape, which provides a heat shield 13, and then a protective sheath 14 for instance of polyethylene or polyvinylchloride is extruded around the assembly.

The relatively high temperature needed for the extrusion of the plastics protective sheath 13 can present some problems with regard to the dimensional stability of the reinforcement member if the heat shielding is not adequate. Oriented PETP, produced

by stretching at a relatively low temperature well below the melting point, is liable to shrink if subsequently heated to a higher temperature. This problem of possible shrinkage can be alleviated by making the reinforcement member out of oriented material which has been subjected, after orientation, to a heat treatment designed to improve its dimensional stability.

In a modification of the above described construction the reinforcement member is made from a high tensile aromatic polymer. Recently such a polymer in the form of fibres has become available under the trade mark Kevlar. This exhibits a Young's modulus in the order of 10,000 kg/mm^2.

In United Kingdom Patent Specifications Nos. 1,425,928 (BICC) and 1,456,755 (Pirelli), there are described optical fibre cable constructions in which, instead of separately stranding sheathed optical fibres around a strength member, the fibres are assembled as a group on or in a tape, and then stranded around the strength member as a pre-assembled group. We make no claim to optical fibre cable constructions in which a plurality of optical fibres are stranded around the strength member in a pre-assembled group.

In United Kingdom Patent Specifications Nos. 1,448,793 (Post Office) and 1,457,868 (Siemens) there are described optical fibre cable constructions in which around a central strength member are disposed a plurality of compartments or chambers in which optical fibres are loosely accommodated. We make no claim to optical fibre cable constructions in which optical fibres are loosely accommodated in compartments or chambers disposed around a strength member.

In United Kingdom Patent Specifications Nos. 1,425,928 (BICC) and 1,453,402 (Pirelli) there are described optical fibre cable constructions in which a cellular plastics sheath is provided for the central member instead of a solid one in order to provide a soft cushioning bedding for the sheathed optical fibres instead of a firm one. We make no claim to optical fibre cable constructions in which the sheathed optical fibres are stranded around a strength member provided with a cellular plastics sheath.

Subject to the foregoing disclaimers,

WHAT WE CLAIM IS:—

1. An optical fibre cable wherein a plurality of plastics sheathed optical fibres are separately stranded around and directly on to a tensile reinforcement member extending along the neutral axis of the cable, or directly on to a solid sheath covering said reinforcement member, such that the sheathed optical fibres are in direct contact with the reinforcement member or its sheath.

2. A circular cross-section optical fibre cable wherein a plurality of circular cross-section plastics sheathed optical fibres are separately stranded around and directly on to a circular cross-section tensile reinforcement member extending along the axis of the cable, or directly on to a solid sheath covering said reinforcement member, such that the sheathed optical fibres are in direct contact with the reinforcement member or its sheath.

3. An optical fibre cable as claimed in Claim 1 or 2, wherein the reinforcement member is stranded.

4. An optical fibre cable as claimed in Claim 3, wherein the reinforcement member is helically stranded.

5. An optical fibre cable as claimed in Claim 1 or 2, wherein the reinforcement member is a single strand.

6. An optical fibre cable as claimed in any preceding claim, wherein the fibres are laid up in the cable in helices around the reinforcement member.

7. A optical fibre cable as claimed in any preceding claim, wherein the optical fibres are made of glass.

8. An optical fibre cable as claimed in Claim 7, wherein the optical fibres are made of silica.

9. An optical fibre cable as claimed in any preceding claim, wherein the reinforcement member is made at least in part of a plastics material.

10. An optical fibre cable as claimed in Claim 9, wherein the plastics material of the reinforcement member is a molecularly oriented plastics material.

11. An optical fibre cable as claimed in any claim of Claims 1 to 8, wherein the reinforcement member is made at least in part of steel.

12. An optical fibre cable as claimed in any claim of Claims 1 to 8, wherein the reinforcement member is made at least in part of glass.

13. An optical fibre cable substantially as hereinbefore described with reference to the accompanying drawing.

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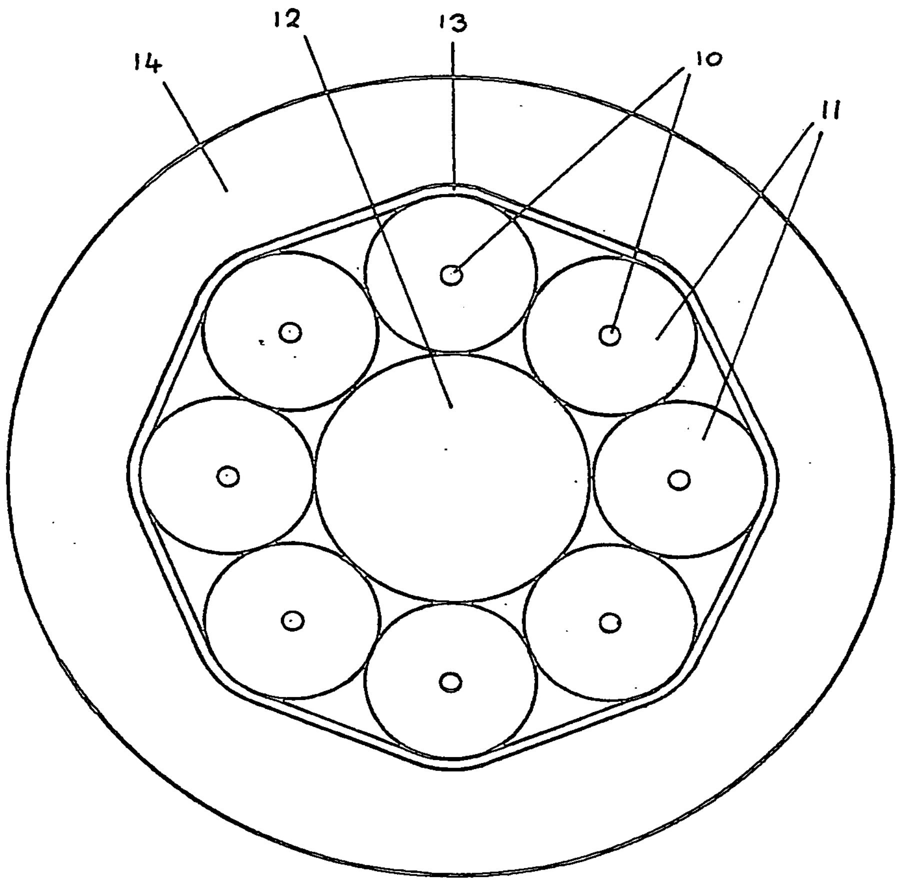
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